IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor	:	Yigal ACCAD
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Title	:	METHODS AND APPARATUS FOR ELECTRONICALLY TRAPPING DIGITAL IMAGES
Attorney Docket No.	:	EFIM0506

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Commissioner for Patents
Mail Stop - Certificate of Corrections
P.O. Box 1450
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REQUEST FOR CERTIFICATE OF CORRECTION 37 CFR 1.322

The enclosed Certificate of Correction (PTO/SB/44) for the above-identified patent is submitted under Rules 322 and 323.

The correction requested involves mistakes made by the U.S. Patent and Trademark Office and Applicant. Such request was necessitated by the discovery of typographical defects in the Specification, Claims and Drawings.

The patentee is entitled to correction of good-faith transcription of a clerical error where "the correction does not involve such changes in the patent as would constitute new matter or would require reexamination" under 35 USC § 254 and § 255. **No new matter is provided with this Certificate of Correction.**

Please direct the Certificate to the address associated with Customer Number 22862.

Authorization is given to the Commissioner to charge the fee of $100 under 37 CFR 1.20(a) and any additional fees due to Deposit Account No.: 707-1445 (Order No. EFIM0506).

Respectfully Submitted,

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO : 7,672,013

APPLICATION NO : 10/718,211

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INVENTOR(S) : Yigal Accad et al.

It is certified that errors appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the face page, in field (73), under "Assignee", delete "Electroncics" and insert - - Electronics - -, therefor.

On Sheet 3 of 25, in FIG. 4, Reference Numeral 62, line 1, delete "Intitialize" and insert - - Initialize - -, therefor.

In column 11, line 26, delete "A" and insert - - Δ - -, therefor.

In column 11, line 50, delete "A" and insert - - Δ - -, therefor.

In column 14, line 2, in claim 1, before "colorant" delete "a".

In column 14, line 47, in claim 9, before "comprises" delete "that".

MAILING ADDRESS OF SENDER:

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Attorney Docket No: EFIM0506

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(45) Date of Patent: Mar. 2, 2010

(54) **METHODS AND APPARATUS FOR ELECTRONICALLY TRAPPING DIGITAL IMAGES**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1127 days.

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G06F 15/00 (2006.01)

(52) **U.S. Cl.** **358/1.9**; 358/518; 358/3.23; 358/3.04; 358/3.05; 358/3.11; 358/3.12; 382/167; 382/271; 382/272; 382/274; 382/205; 382/308

(58) **Field of Classification Search** 358/1.9, 358/518, 3.26, 3.04–3.05, 3.11–3.12; 382/167, 382/274, 271–272, 205, 308
See application file for complete search history.

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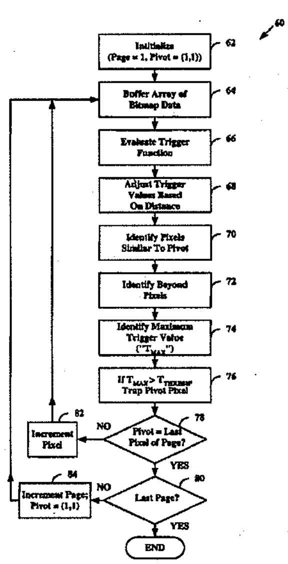
(57) **ABSTRACT**

Methods and apparatus are provided for electronically trapping a selected digital color image pixel. A plurality of pixels that surround the selected pixel are identified, a colorant value of each of the surrounding pixels is compared with a corresponding colorant value of the selected pixel, one of the surrounding pixels is identified to control trapping of the selected pixel, and the selected pixel is trapped based on a relationship between a colorant value of the selected pixel and a corresponding colorant value of the identified controlling pixel.

12 Claims, 25 Drawing Sheets



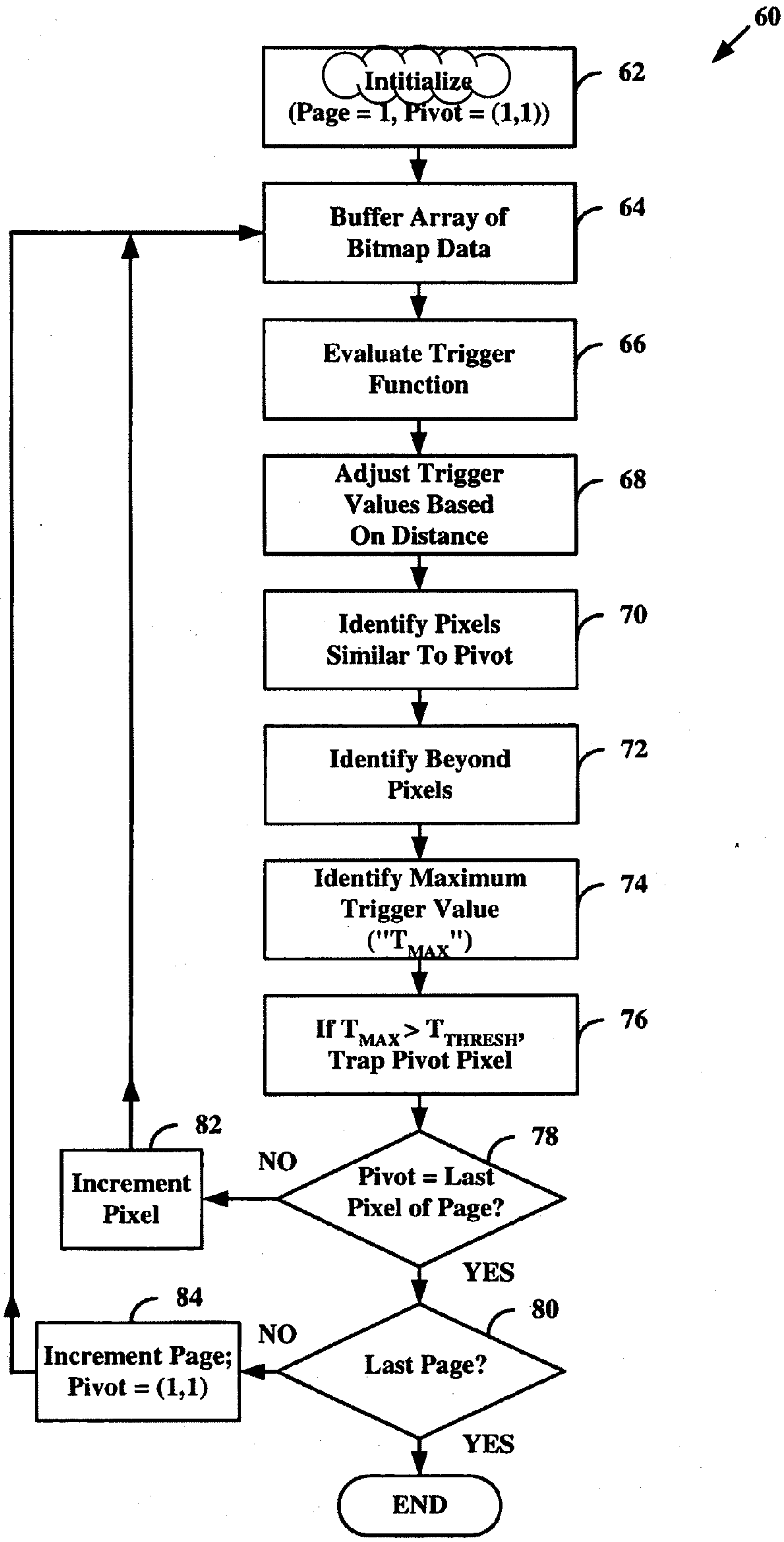

60
Intitialize (Page = 1, Pivot = (1,1))
62
Buffer Array of Bitmap Data
64
Evaluate Trigger Function
66
Adjust Trigger Values Based On Distance
68
Identify Pixels Similar To Pivot
70
Identify Beyond Pixels
72
Identify Maximum Trigger Value ("T_{MAX}")
74
If $T_{MAX} > T_{THRESH}$, Trap Pivot Pixel
76
Pivot = Last Pixel of Page?
78
NO
Increment Pixel
82
YES
Last Page?
80
NO
Increment Page; Pivot = (1,1)
84
YES
END

FIG. 4

grated circuit processor, field programmable gate array or other similar processing device that may be used perform pull trapping steps in accordance with this invention. Persons of ordinary skill in the art will understand that page buffer **122**, ROI buffer **124**, processor **126** and trapping logic **128** each may be implemented on separate hardware and/or software, or may be combined in one or more hardware and/or software devices.

In addition, trapping logic **128** may be implemented using pipelined processing techniques to reduce the time required to perform pull trapping steps in accordance with this invention. Referring now to FIG. **21**, an exemplary pipelined implementation of trapping logic **128** is described. As shown in FIG. **21**A, trapping logic **128** receives region of interest data, and includes a series of processing stages, each of which performs a single operation. In particular, trapping logic **128** includes Δ Calculation stage **130**, Trigger Calculation stage **132**, Similar Calculation stage **134**, Trigger Buffer **136**, Beyond Determination stage **138**, T_{MAX} Determination stage **140**, and Trapping Determination stage **142**. In accordance with known pipelined processing techniques, each of stages **130**-**142** operates under control of a digital clock signal, and the output of each stage is gated before being provided to the subsequent stage on the next clock cycle.

FIG. **21**B illustrates the timing operation of trapping logic **128**. In particular, during a first clock cycle, Δ Calculation stage **130** receives pixel data for region of interest ROI(i), including pivot pixel Pivot(i), and calculates colorant difference values for pixels in ROI(i) in accordance with equation (4). In the second clock cycle, Trigger Calculation stage **132** and Similar Calculation stage **134** each receive the colorant difference values for ROI(i) calculated during the first clock cycle, and Δ Calculation stage **130** receives pixel data for region of interest ROI(i+1), including pivot pixel Pivot(i+1), where Pivot(i+1) is the next successive pixel in page buffer **122** and ROI(i+1) is the next successive region of interest in ROI buffer **124**. Also during the second clock cycle, Trigger Calculation stage **132** calculates distance-adjusted trigger values for pixels in ROI(i) in accordance with equations (2) and (5), and Similar Calculation stage **134** determines similar flags for pixels in ROI(i) in accordance with equation (7).

In the third clock cycle, Trigger Buffer **136** receives the distance-adjusted trigger values for pixels in ROI(i) calculated during the second clock cycle, Beyond Determination stage **138** receives the distance-adjusted trigger values and the similar flags for pixels in ROI(i) calculated during the second clock cycle, Trigger Calculation stage **132** and Similar Calculation stage **134** each receive the colorant difference values for ROI(i+1) calculated during the second clock cycle, and Δ Calculation stage **130** receives pixel data for region of interest ROI(i+2), including pivot pixel Pivot(i+2), where Pivot(i+2) is the next successive pixel in page buffer **122** and ROI(i+2) is the next successive region of interest in ROI buffer **124**. Also during the third clock cycle, Beyond Determination stage **138** determines the beyond pixels for pixels in ROI(i) as described above, and accordingly resets the distance-adjusted trigger values in Trigger Buffer **136** for beyond pixels in ROI(i).

In the fourth clock cycle, T_{MAX} Determination stage **140** receives the distance-adjusted trigger values for pixel in ROI (i) calculated during the third clock cycle, Trigger Buffer **136** receives the distance-adjusted trigger values for pixels in ROI(i+1) calculated during the third clock cycle, Beyond Determination stage **138** receives the distance-adjusted trigger values and the similar flags for pixels in ROI(i+1) calculated during the third clock cycle, Trigger Calculation stage **132** and Similar Calculation stage **134** each receive the colorant difference values for ROI(i+2) calculated during the third clock cycle, and Δ Calculation stage **130** receives pixel data for region of interest ROI(i+3), including pivot pixel Pivot(i+3), where Pivot(i+3) is the next successive pixel in page buffer **122** and ROI(i+3) is the next successive region of interest in ROI buffer **124**. Also during the fourth clock cycle, T_{MAX} Determination stage **140** identifies the maximum distance-adjusted trigger value $T_{MAX}(i)$ and the corresponding Trigger Pixel(i) for ROI(i).

In the fifth clock cycle, Trapping Determination stage **142** receives colorant values of pivot pixel Pivot(i) and Trigger Pixel(i) for ROI(i) identified during the fourth clock cycle, T_{MAX} Determination stage **140** receives the distance-adjusted trigger values for pixel in ROI(i+1) calculated during the fourth clock cycle, Trigger Buffer **136** receives the distance-adjusted trigger values for pixels in ROI(i+2) calculated during the fourth clock cycle, Beyond Determination stage **138** receives the distance-adjusted trigger values and the similar flags for pixels in ROI(i+2) calculated during the fourth clock cycle, Trigger Calculation stage **132** and Similar Calculation stage **134** each receive the colorant difference values for ROI(i+3) calculated during the fourth clock cycle, and Δ Calculation stage **130** receives pixel data for region of interest ROI(i+4), including pivot pixel Pivot(i+4), where Pivot(i+4) is the next successive pixel in page buffer **122** and ROI(i+4) is the next successive region of interest in ROI buffer **124**. Also during the fifth clock cycle, Trapping Determination stage **142** performs trapping on the colorant values of pivot pixel Pivot(i) based on the colorant values of Trigger Pixel(i), and provides trapped pivot pixel $Pivot_T(i)$. Thus, each stage of exemplary trapping logic **128** operates in lockstep fashion with the other stages, and trapping calculations are concurrently performed with respect to five different regions of interest to reduce the time required to trap print image data **36**.

To further reduce the time required to perform pull trapping steps in accordance with this invention, the various stages of trapping logic **128** may be implemented using parallel processing techniques. Referring now to FIG. **22**, an exemplary parallel processing implementation of the stages of FIG. **21**A is described. In this example, the trapping circuitry processes data in a region of interest defined using the trapping window shown in FIG. **5**D, which includes sixty-eight pixels surrounding pivot pixel Pivot, with each pixel including C, M, Y and K colorants. Accordingly, as shown in FIG. **22**A, the input to Δ Calculation stage **130** includes two hundred seventy-two (68×4=272) data lines for each region of interest. Further, Δ Calculation stage **130** includes two hundred seventy-two differencing circuits **150**, where each differencing circuit **150** calculates the colorant difference for a single colorant of a single pixel in the region of interest.

The output of Δ Calculation stage **130** includes pivot pixel Pivot and the two hundred seventy-two colorant differences for the pixels that surround Pivot. Trigger Calculation stage **132** receives the outputs of Δ Calculation stage **130**, and includes sixty-eight trigger calculation circuits **152** that each calculate a distance-adjusted trigger value for a corresponding one of the sixty-eight pixels in the region of interest. The output of Trigger Calculation stage **132** includes pivot pixel Pivot and the sixty-eight distance-adjusted trigger values. Similar Calculation stage **134** receives the two hundred seventy-two colorant differences from Δ Calculation stage **130**, and includes sixty-eight similar calculation circuits **154** that each determine the similar flag for a corresponding one of the sixty-eight pixels in the region of interest. The output of Similar Calculation stage **134** includes the sixty-eight similar flags.

As shown in FIG. 22B, Trigger Buffer stage **136** receives the outputs of Trigger Calculation stage **132**, and includes sixty-eight memory circuits **156** that each store a corresponding one of the sixty-eight trigger values. Beyond Determination stage **138** receives the outputs of Trigger Calculation stage **132** and Similar Calculation stage **134**, and includes sixty-eight beyond circuits **156** that each determine the beyond status of a corresponding one of the sixty-eight trigger values. The output of Beyond Determination stage **138** is used to modify the sixty-eight trigger values stored in Trigger buffer stage **136**. The output of Trigger buffer stage **136** includes pivot pixel Pivot and the sixty-eight modified trigger values. T_{MAX} Determination stage **140** receives the pivot pixel Pivot and the sixty-eight modified trigger values, and identifies the maximum distance-adjusted trigger value T_{MAX} and the corresponding Trigger Pixel. Trapping Determination stage **142** receives pivot pixel Pivot and Trigger Pixel and performs trapping based on the colorant values of the Trigger Pixel. The output of Trapping Determination stage **142** is the trapped pivot pixel $Pivot_T$.

The foregoing merely illustrates the principles of this invention, and persons of ordinary skill in the art can make various modifications without departing from the scope and spirit of this invention.

We claim:

1. A computer-implemented method for electronically trapping a first digital color image pixel comprising a plurality of colorant values, the method comprising:
- identifying, with a computer, a trapping window comprising a plurality of pixels that surround the first pixel, each of the surrounding pixels comprising a plurality of colorant values;
- determining, with the computer, a difference between a sum of magnitudes of differences between colorant values of each of the surrounding pixels and corresponding colorant values of the first pixel, and a magnitude of a sum of differences between colorant values of each of the surrounding pixels and corresponding colorant values of the first pixels to obtain a trigger value for each of the surrounding pixels;
- adjusting, with the computer, the trigger values according to the distance between the first pixel and each surrounding pixel to obtain a distance adjusted trigger value for each of the surrounding pixels;
- comparing, with the computer, the adjusted trigger values for each of the surrounding pixels to a trigger threshold;
- identifying, with a computer, any of the surrounding pixels where the adjusted trigger value for the surrounding pixel exceeds the trigger threshold;
- identifying, with the computer, a trigger pixel from the surrounding pixels with the adjusted trigger value that exceeds the trigger threshold with a maximum trigger value; and
- trapping, with the computer, the first pixel based on colorant values of the first pixel and a colorant values of the trigger pixel.

2. The method of claim **1**, wherein the trapping window comprises a circular shape.

3. The method of claim **1**, wherein the trapping window comprises an elliptical shape.

4. The method of claim **1**, wherein each pixel that exceeds the trigger threshold indicates an edge that requires trapping.

5. The method of claim **1**, wherein the step of trapping pulls a trap from the trigger pixel to the first pixel.

6. The method of claim **1**, wherein the colorant values comprise cyan, magenta, yellow and black colorants.

7. An apparatus for electronically trapping a first digital color image pixel comprising a plurality of colorant values, the apparatus comprising:
- means for identifying a trapping window comprising a plurality of pixels that surround the first pixel, each of the surrounding pixels comprising a plurality of colorant values;
- means for determining a difference between a sum of magnitudes of differences between colorant values of each of the surrounding pixels and corresponding colorant values of the first pixel, and a magnitude of a sum of differences between colorant values of each of the surrounding pixels and corresponding colorant values of the first pixel to obtain a trigger value for each of the surrounding pixels;
- means for adjusting the trigger values according to the distance between the first pixel and each surrounding pixel to obtain a distance adjusted trigger value for each of the surrounding pixels;
- means for comparing the adjusted trigger values for each of the surrounding pixels to a trigger threshold;
- means for identifying any of the surrounding pixels where the adjusted trigger value for the pixel exceeds the trigger threshold;
- means for identifying a trigger pixel from the surrounding pixels with the adjusted trigger value that exceeds the trigger threshold with a maximum colorant difference value; and
- means for trapping the first pixel based on colorant values of the first pixel and colorant values of the trigger pixel.

8. The apparatus of claim **7**, wherein the trapping window comprises a circular shape.

9. The apparatus of claim **7**, wherein the trapping window that comprises an elliptical shape.

10. The apparatus of claim **7**, wherein each pixel that exceeds the trigger threshold indicates an edge that requires trapping.

11. The apparatus of claim **7**, wherein the means for trapping pulls a trap from the trigger pixel to the first pixel.

12. The apparatus of claim **7**, wherein the colorant values comprise cyan, magenta, yellow and black colorants.

* * * * *